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**Abstract**

# POISON CONTROL OF THERMAL REACTORS

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This paper covers the use of both burnable poisons and soluble poisons for reactor control.

The burnable poison which has proved most useful to date is boron. Even considering epithermal fission, the ratio of the boron to U-235 cross sections, averaged over all energies of reactor interest, is almost independent of the thermal spectrum. While the helium resulting from the disintegration of boron-10 is objectionable metallurgically, dilute boron loadings appear to be acceptable.

A large number of elements other than boron have been considered for use as burnable poison and appear to have merit for specialized applications. For example, erbium will in some cases result in a more negative temperature coefficient of reactivity, thus enhancing self-protection, and for this reason is employed in the TRIGA reactors.

Very high cross-section elements, such as cadmium and samarium, are sometimes employed as supplementary burnable poisons to increase the shutdown of a new clean core.

Mixing burnable poison homogeneously with the fuel is often inadequate to obtain the objectives of high fuel burnup and long endurance. In this case it becomes necessary to install the burnable poison in lumped or self-shielded form, or to use combinations of homogeneous and lumped poisons.

The application of burnable poisons to the integrated designs of a reactor is stressed, using the Shippingport cores as examples in which the burnable poisons are used to attain extended life and improved power distribution. Practical methods of calculating the effects of lumped as well as homogeneous burnable poisons and design considerations are presented.

The use of combinations of burnable poisons and the use of multi-isotope poisons are discussed. Both local and gross zoning of burnable poisons and fuel are included, as is recent work on shaped burnable poisons.

In the case of uniformly enriched reactors employing fuel management, recent work indicates that by use of suitable combinations of self-shielded poisons a single burnable poison loading can be utilized for the useful life of the fuel, thus avoiding the need to replace the burnable poison when the fuel is reshuffled.

In connection with the application of burnable poisons to practical reactor design, it is of great importance to determine the ratio of burnable poison absorptions to fuel fissions, since this quantity essentially determines the depletion of the poison relative to fuel. In the case of boron, a special problem is presented experimentally in that boron does not activate. The use of various "spiking" materials such as manganese, vanadium and nickel has been explored. Agreement has been obtained in the results obtained from each of these materials. Further, the experimental results are now in good agreement with extensive Monte Carlo calculations.

Neutron absorbing material dissolved as chemicals in the coolant moderator of a water reactor has been used for cold shutdown and during power operation. Reactor core design considerations are noted such as the possibilities for increased power densities, reduced control rod requirements, and implications of moderator temperature coefficient with respect to control and stability of the reactor. The paper covers the means whereby chemical shim is added, controlled, and withdrawn from the reactor.